SQT

E85-10053
NASA CR-174227

Task Assignment 132
November 1984

CHARACTERIZING THE SCIENTIFIC POTENTIAL OF SATELLITE SENSORS

GSFC ATR – Dr. J. Barker
SAR Task Leader – Dr. Y. Lee

Task Objective:

The objective of this task is to provide analytical and programming support to characterize the potential of the Landsat Thematic Mapper (TM) digital imagery for scientific investigations in the earth sciences and in terrestrial physics. Secondary objectives of this task include providing technical support to define lower atmospheric and terrestrial surface experiments for the space station and providing technical support to the Research Optical Sensor (ROS) study scientist for advanced studies in remote sensing.

Work Performed:

The following work was performed in the areas indicated.

100 TM Radiometric Calibration

As part of the process of radiometrically characterizing raw TM imagery, systematic radiometric errors have been identified and approximate empirical corrections have been developed. A total of 17 subscenes have been generated this month, including two raw images and 15 calibrated or corrected images, for individual single-band illustrations of each type of error. Eleven programs have been developed for performing calibration and correction on raw 512 x 512 images. In addition, program BTMASK.FOR has been revised to create a full scene bright target boundary mask.

The algorithm for creating a bright target boundary mask developed here is suitable only for the specific San Francisco scene 40392-18152, where a stack of cloud was located as a solid triangular mass along the Pacific coast in the south-western position of the scene. The clouds appear around scan 70 from the top of the scene. The east side of the cloud boundary can easily be masked by thresholding from the east side of the scene to the west side of the scene. The west side of the cloud extends past the boundary of the imagery. The files IMASK.BTS and BMASK.BTS contain the east side cloud boundary mask and the west side cloud boundary mask, respectively, have been created for the San Francisco scene 40392-18152.

The 11 calibration and correction programs are described as follows.

BTIPS – This program performs TIPS radiometric calibration on the raw image. It was the "applied" final adjusted gains and biases, with histogram equalization, from the TIPS QA report and applies the calibration to the raw CCT-BT or CCT-A1 data line-by-line.

BMEAN – This program calculates the mean for an individual channel of an image for the histogram equalization applied within the TRAPP calibration.

(E85-10053) NASA-CR-174227) CHARACTERIZING THE SCIENTIFIC POTENTIAL OF SATELLITE SENSORS (SAR, Inc.) 13 p HC A02/MF A01 CSCL 08B G3/43 Unclas 00053 N85-16249

BSD – This program calculates the standard deviation for an individual channel of an image for the histogram equalization during TRAPP calibration.

BTRAPP – This program performs TRAPP radiometric calibration on a raw image. The apparent gains and offsets are obtained from the TRAPP report and are converted to the normalized gains and bias by using the RMIN and RMAX obtained from the TIPS QA report. The histogram equalization then is applied to the normalized gains and bias by Z transform, using means and standard deviations calculated from BMEAN and BSD. The reference channel for the histogram equalization has been set to channel 9 of each band. The TRAPP radiometric calibration then is performed on the raw image line by line.

CBTS – This program performs bright target saturation (BTS) correction. It reads in the BTS amplitudes and recovery time constants from file TIME.BTS and the BTS boundary mask from files IMASK.BTS and BMASK.BTS. The program reads in a raw image file and a raw background file, converts these files to 16–bit data by multiplying by 65535/255, performs correction pixel by pixel, and outputs four calibrated files: a BTS corrected image file, a BTS corrected background file, the difference image for the image file correction, and the difference image for the background file correction.

CSCSC – This program calculates the mask for scan correlated shift (SCS). It reads in the BTS–corrected background file and calculates the mean for each background line. It then finds the maximum and minimum of the means and sets threshold values as the average of the maximum and minimum. The SCS mask then can be determined by reference to the threshold values, and the shift amplitudes can be calculated.

CSCS – This program performs SCS correction. It obtains the SCS mask from output of CSCSC, then applies correction on the BTS corrected image and background files line by line. The output includes the BTS+SCS corrected image file, the BTS+SCS corrected background file, the difference image for the image file SCS correction, and the difference image for the background file SCS correction.

CCN – This program performs coherent noise (CN) correction. It calculates the FFT for single band resequenced data for both BTS+SCS corrected image and background files. A notch filter is created by thresholding the background FFT spectrum. The correction is then made by performing inverse FFT on the notched FFT spectra. The output includes the BTS+SCS+CN corrected image file, BTS+SCS+CN corrected background file, the difference image for the image file CN correction, and the difference image for the background file CN correction.

CMEAN – This program calculates the mean for individual channels for this BTS+SCS+CN corrected image.

CSD – This program calculates the standard deviation for individual channels for the BTS+SCS+CN corrected image.

CTRAPP – This program performs TRAPP radiometric calibration on the BTS+SCS+CN corrected image. The procedures are the same as for BTRAPP, except the mean and standard deviation are calculated from CMEAN and CSD.

The output image files for programs BTIPS and BTRAPP are in eight-bit BYTE format. The output files for programs CBTS, CSCS, CCN, and CTRAPP are in 16-bit INTEGER*2 format, value from 0 to 65535.

TIPS radiometric calibration can be characterized by comparison of output files from BTIPS and CTRAPP. The TM systematic radiometric errors, BTS, SCS, and CN, can be characterized from the difference images created in each correction step. The TM image quality can then be assessed by using calibrated files from BTIPS, BTRAPP, and CTRAPP.

110 Coherent Noise (CN)

Two programs, CNFFT and RCNFFT, have been developed for coherent noise correction. CNFFT performs the correction on a line-by-line basis. RCNFFT resequences one-band image data and performs correction on a scan-by-scan basis. Programs have been tested on the band 1 San Francisco scene background file. The corrected images look similar. A wood-grained pattern of the noise images has been noticed. Program SAMPLE.PDF has been developed for creating a single channel image.

130 Bright Target Saturation (BTS)

The amplitudes and time constants for each band of Landsat-4 TM have been optimized by examining the corrected images visually. The equation for BTS correction is

$$CB(X)=-C1*EXP(-X/C2)+C3*EXP(-X/C4)$$

C1, C2, C3, and C4 for bands 2 and 3, are listed as follows:

Band #	C1 (DN)	C2 (mf)	C3 (DN)	C4 (mf)
2	4.12	978	0.52	7778
3	4.82	978	0.62	7778

where DN = digital number, and mf is the minor frame sample location.

210 Image Processing on LAS/VAX

A scheme for radiometrically characterizing TM data and TM image quality assessment has been developed and is shown in Figure 1. This involves comparison of calibrated and corrected images described in subtask 100. Two figures of merit have been suggested: first, quantification of the changes in the contour of the land-water interface before and after calibration or correction; second, quantification of the changes of the differential or cumulative histogram before and after correction. Two other San Francisco scenes, 40200-18152 and 40168-18143, have been suggested as the ground truth for evaluating the noise corrections on scene 40392-18152.

220 Image Processing on HP-3000/IDIMS

A training session was held to train additional task personnel in the usage of the IDIMS and existing command files to make prints of Landsat TM images.

The command files that produce black-and-white and one-cycle pseudocolored pixel prints of seven bands of TM data were rewritten. The options to process 384 lines at two times expansion and to put the band number in the annotation block were added to the command files. In addition, the one-cycle pseudocoloring command file was changed to make all saturated pixels white and all zero-valued pixels black. The procedure applies an equal area stretch to enhance each band.

The original command files were split into a sequence of three processses. The first command file defines the annotation, image size and location, title, bands, image name, and the starting output tape file number. The second command file creates the enhanced subimage, the annotation and title blocks, the histogram and gray wedge, and the tic marks by using the DeAnza display processor software. The third file consists of a batch job that 1) does all the disk-to-disk operations, such as image insertion, magnification, and mosaics, and 2) writes the resulting image to a tape for input to the Optronics film recorder program.

This new procedure for creating prints has the following advantages: 1) the user only needs to change the contents of one command file to make either black-and-white and pseudocolored prints 2) documentation in the form of commented lines has been added to the definition file 3) the definition file contains the information that will vary from scene to scene, and no image processing commands are imbedded in the command file and 4) the addition of a batch process requires less waiting time for the user and costs less to process because the display processor is not being used while in the batch mode. The procedure to make pixel prints is now standardized for seven bands of TM data. A sample output is shown in Figure 2.

300 Production Support

Forty-five tapes from SBRC have been scanned completed and found there are 3075 blocks for all BRU data except for two special tapes that have 2890 blocks (#1051, #1057), and 1750 - 1850 blocks for BURST data. A chosen BRU data tape (#1073) has been run successfully (eight-window option), two BURST data tapes have been

tested without any problems. An effort was made to transfer image data of subscene of White Sands and San Francisco, as well as to create image data of subscene of San Francisco for producing pseudocolor pixel prints. Command files on HP-3000 and image file on VAX 11/780 were created to perform pseudocolor prints. Nine new files have been built under TAE to generate histogram of subimage. One in-orbit data set (Birmingham) has been processed by request.

400 Software Development

410 Scan Time Code Table

A time code table was created and became part of TRAPP program's output. A significant change was made on TRAPP routine RCINJBRU, RCTIME, and RCASCIITM. Listed below are the brief descriptions for the added parts of these routines:

In routine RCINJBRU, about 100 line codes were added to perform the calculation of DPO, DDPO, mean, standard deviation, outlier test, as well as DDP table output.

In routine RCTIME, two line codes were added to obtain the scan start time up to 10^{-4} second.

In routine RCASCIITM, 12 line codes were added so each scan line starting time can be stored in the file called TIME.DAT.

420 Linear Regression Coefficient Tables, Part I: Background (B) versus Start of Scan (PO), Difference Between Adjacent Scans (DPO), and Difference of DPO from the average value of DPO (DDPO).

Eight tables of linear regression coefficient with shutter background versus PO (or DPO or DDPO) are the intercept, AO (DN), the standard deviation of intercept, SDAO (DN), slope, A1 (DN/sec), standard deviation of slope, SDA1 (DN/sec), correlation coefficient R, test on residuals for randomness, standad deviation of B (DN), and unaccounted variance, 100 (1–R**2). The following new routines have been implemented and tested:

- Subroutine RCORR1 – this routine performs the calculation of A0, A1, R via equation B=A0+A1 (P0).
- Subroutine RCCORR01 – this routine performs eight table output in two pages.
- Subroutine MEANVAR – this routine computes the odd mean, even mean, all mean, odd standard deviation, even standard deviation, all standard deviation for the AO, A1, SDAO, SDA1, R, test of normality, B, and 100 (1–R**2).
- Subroutine RENORMAL – this routine uses Lilliefor's algorithm to test whether the input data set is normal dist. or not. The implementing procedures are as follows:

(a) Compute $\langle X \rangle$ and R^2 from population $X_{(i)}$;

(b) Sort $X_{(i)}$

(c) Determine pilot data file Y_i by $Y_i = (X_{(i)} - \langle X \rangle)/R$;

(d) From table of normal dist., $Y = Fo(X_i, \bar{X}, R)$ is then found

(e) Obtain $\hat{\delta}_i$ by

$$\hat{\delta}_i = \mathrm{Max}[F_o(X_{(i)}; \bar{X}, S) - \frac{i-1}{n}, \frac{i}{n} - F_o(X_{(i)}; \bar{X}, S)],$$

(f) Determine $\hat{D}_n$ by $\hat{D}_n = \max_{1 \le i \le n} (\hat{\delta}_i)$

(g) Compare $\hat{D}_n$ value with the tables. The hypothesis Ho will be either rejected or accepted.

After adding the above subroutines, the following old routines had been modified:

- RCNMAIN – About 10 line codes were added to perform the user's options of P0, DP0, and DDP0 for linear regression coefficient table.
- RCUSERIN – One new argument was added to pass the option the user chooses.
- RCINJBRU – About 10 line codes and one argument were added to select the right option.

500 MSS Coherent Noise Analysis

Two batch jobs were set up to transform one scan of calibrated Landsat–4 and –5 A–tape MSS data back to uncalibrated B–tape data and to plot the Fourier–transformed noise amplitudes. Two additional batch jobs were set up to transform six scans of A–tape data back to B–tape data for Landsat–4 and –5. A batch job was set up to calculate the Fourier transform magnitudes of six scans and to average the channel magnitudes of the six scans. Another batch job was set up to make plots on the Versatec plotter of the average Fourier magnitude of six scans versus frequency for the 24 channels of Landsat–4 and –5.

Both B–tape and A–tape data for a 512 x 512 subimage of MSS data were entered into IDIMS from March 16, 1984, scene (path=27, row=28). The applied histogram plus internal calibrator gain and bias correction terms were extracted for each channel within one scan of the Landsat–5 data files. The procedure to convert the A–tape data back to B–tape data was tested on six channels, and the results were compared to the B–tape data files. The inversion process was successful except for a few inconsistencies that were reported to B. Markham and the ATR in a memorandum.

The time code is embedded within each scan of the MSS A–tape image data. It may be useful in the analysis and filtering of the coherent noise within Landsat–4 MSS data. Task personnel are looking into writing a program on the LAS system to extract the time codes from the image files.

700 Image Science Studies

The contouring program on the I^2S display system was tested on TM band 1 of the Grand Bahamas Bank scene. The program takes about 10 minutes to run for a 512 x 512 subimage. Both smoothing the data with a 3 x 3 filter or interpolating the data to a 15-meter grid cell size improved contouring results.

Signficant Accomplishments:

Task personnel developed software for the time code table with outlier test (95 percent confidence interval). This is an important approach because those data can be used to do further analysis such as correlation coefficient, characteristic of timer, and test other data to see if they are correct.

Problem Areas:

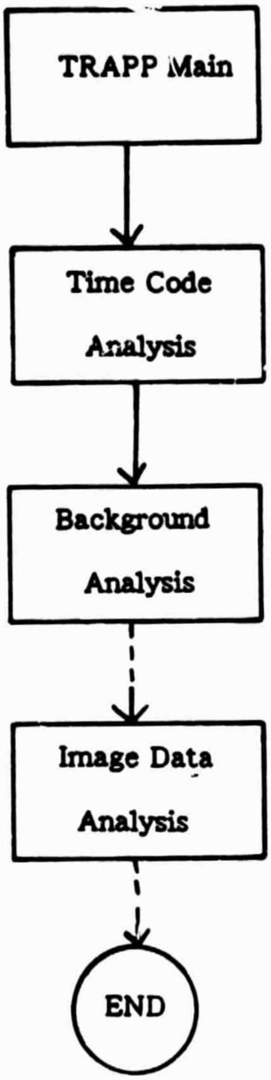
There are two major problems that occur when the TRAPP program is running:

(1) VAX 11/780 System:

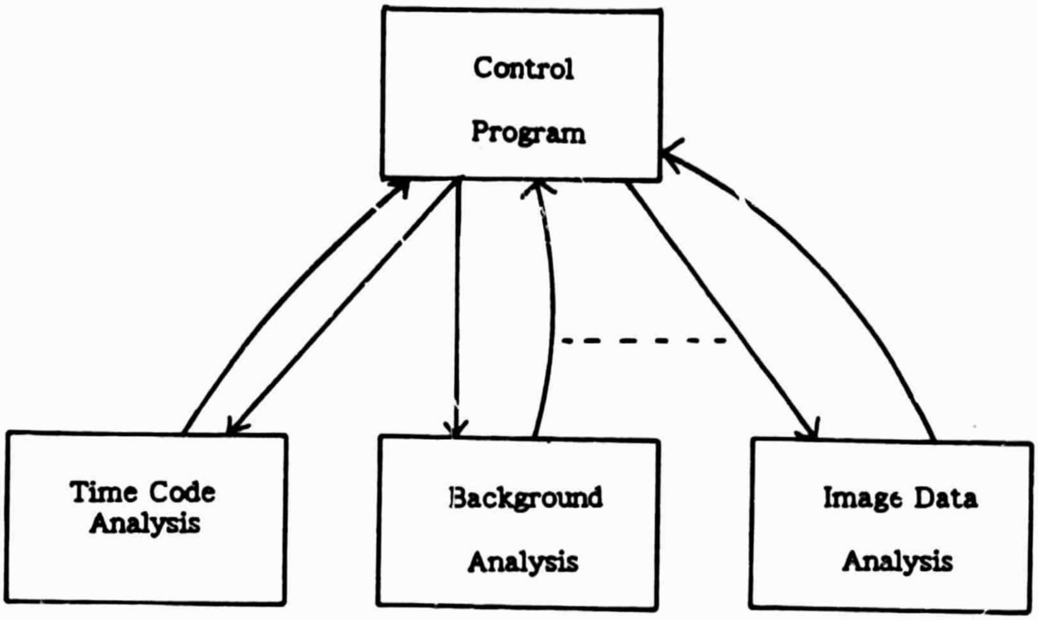
There are only two user's disks available and 35,000 block size assigned to this project. Since TRAPP is a huge program, most space was occupied by source codes (.FOR), object files (.OBJ), load module (.EXE), and included files (.INC). Usually, only about 4500 blocks are left when TRAPP is executed. There are two magnetic tape drivers available for all users and, unfortunately, TRAPP is heavily dependent on tape drivers. Therefore, a lot of time was spent in the queue. A data base should be built upon resident disks to avoid congestion.

(2) TRAPP Program:

The structure of the TRAPP program is a series; that is, it has benchmark architecture. However, this program is continuously modified or added in some specified parts and, therefore, it is very time-consuming for the programmer to perform. A parallel structure is suggested for TRAPP. For instance, if TRAPP has 30 objective functions, it will be taken apart into 20-30 individual programs, and one control driver program should be written to take control over all the individual programs. When the user runs a specified part of TRAPP program, he doesn't need to run through the whole program. Instead, he will enter a specified command defined in the control program, and obtain what he needs. The following diagrams show the structure difference between the old and the new proposed architecture of the TRAPP program. Due to funding cut-backs, SAR does not have the resources to correct these severe problems in the TRAPP program.



Old Architecture for TRAPP (benchmark structure)



New Architecture for TRAPP (analysis structure)

Task Assignment 132
November 1984

Schedule Conformance:

Work is proceeding as planned.

Work Planned for Next Month:

100 TM Radiometric Calibration

Task personnel will develop and process calibrated and corrected images.

210 Image Processing

SAR will develop and process calibrated and corrected images.

300 Production Support

SAR personnel will continue to copy the SBRC tapes, merge six data files onto one tape, and process any SBRC tape upon the ATR's request.

400 Software Development

A task member will continue to implement and test the randomness algorithms and reformat the output tables for linear regression coefficient according to the ATR's request. If there is time left, the B versus B within the correlation table (21 tables, 7 pages) will be performed.

Deliverables Submitted:

Graphics:	48 plots of average magnitude versus frequency for 24 channels of Landsat-4 and -5 for the Pensacola, FL, scene
Originator:	W. Hallada
Listings:	Listings from CALFILE and CALDUMP tapes for TM World Reference System location path 28, row 36
Originator:	J. Wang

Computer Utilization:

The estimated computer time used this month is as follows:

Minutes	Computer
1656 (wall clock)	HP-3000 (IDIMS)
100 (wall clock)	HP-3000 (ERRSAC)
200 (wall clock)	VAX 11/780 - LAS

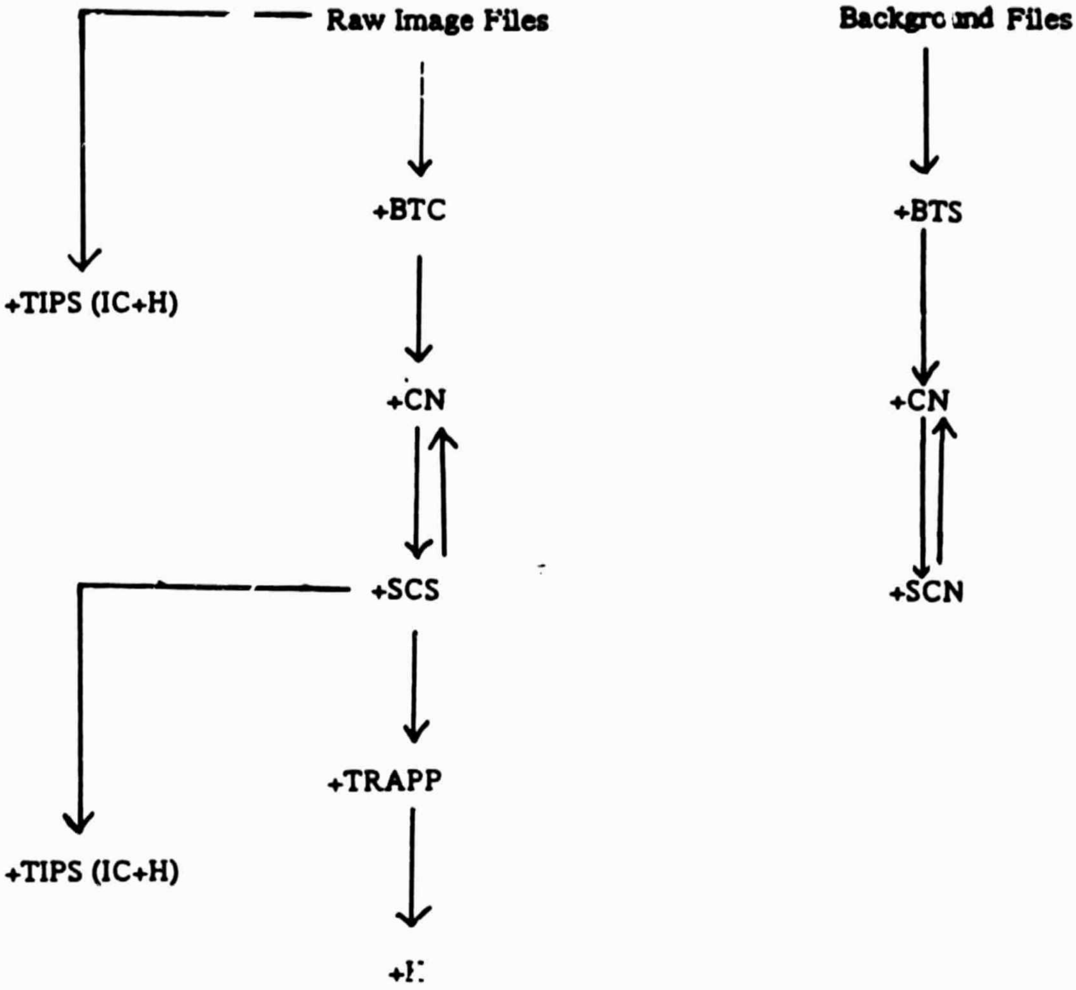

Raw Image Files
Background Files
+BTC
+BTS
+TIPS (IC+H)
+CN
+CN
+SCS
+SCN
+TRAPP
+TIPS (IC+H)

Figure 1

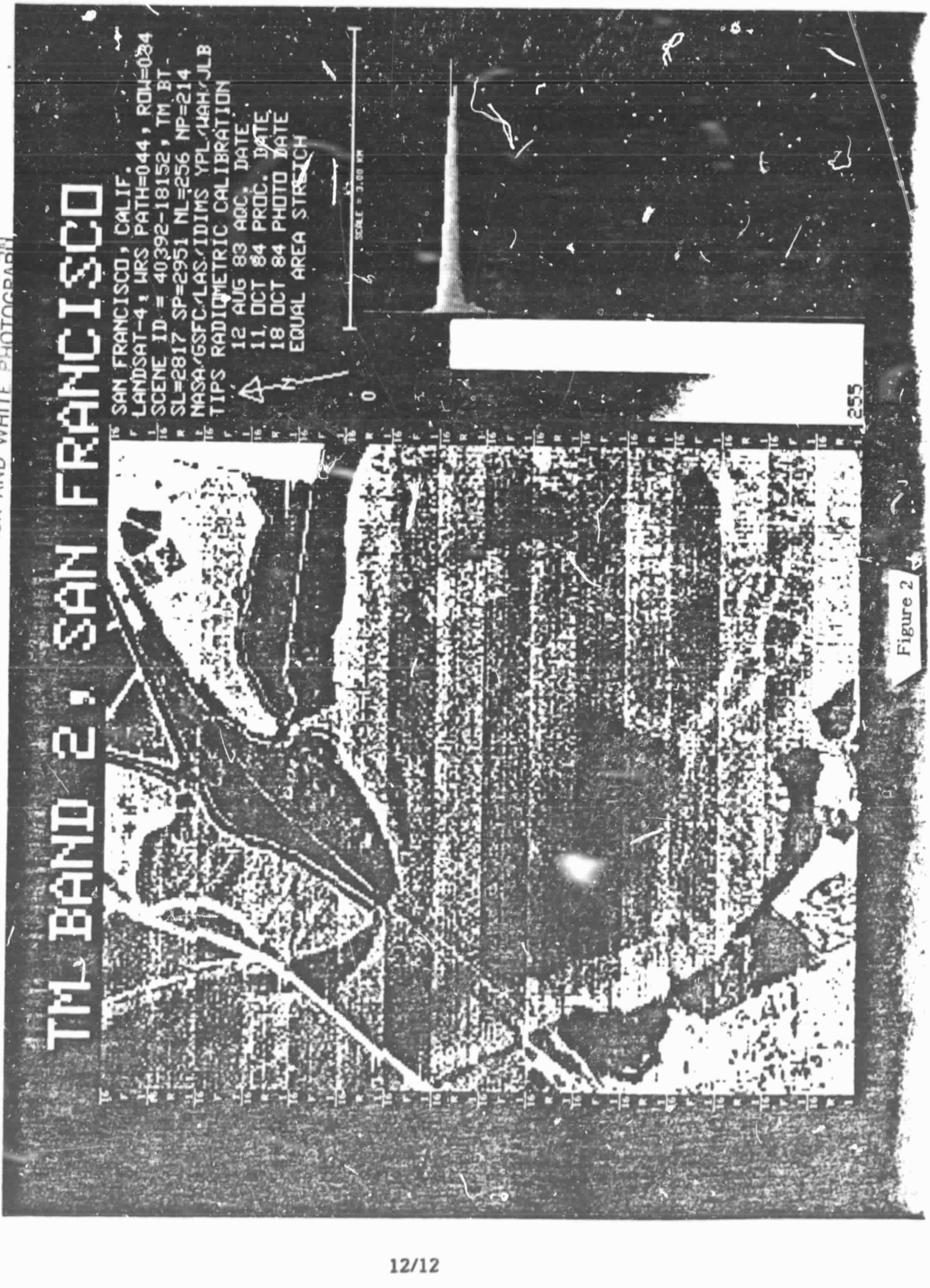

TM BAND 2: SAN FRANCISCO
SAN FRANCISCO, CALIF.
LANDSAT-4; WRS PATH=044, ROW=034
SCENE ID = 40392-18152, TM BT
SL=2817 SP=2951 NL=256 NP=214
NASA/GSFC/LAS/IDIMS YPL/WAH/JLB
TIPS RADIOMETRIC CALIBRATION
12 AUG 83 ACQ. DATE
11 OCT 84 PROC. DATE
18 OCT 84 PHOTO DATE
EQUAL AREA STRETCH
N
0
255

Figure 2

Task Assignment 132
November 1984

SUBTASK #00
FINANCIAL DATA AND LABOR-HOUR UTILIZATION

Financial Data

Cumulative total to date:	$ 23,871
Projected total to complete:	$ 100,305
CTR estimated total:	$ 124,176

Labor-Hour Utilization

	Hours this Month		Cumulative Hours	
Category	On-Site	Off-Site	On-Site	Off-Site
PM		3.4		8.2
TAM		8.0		23.0
LPA	22.5	22.5	44.5	50.5
SAP	45.0		97.0	
AP	112.0		196.0	84.0
JAP	152.0		320.0	
SP	152.0		248.0	40.0
Support	16.0	38.9	16.0	82.2
	499.5	72.8	921.5	287.9